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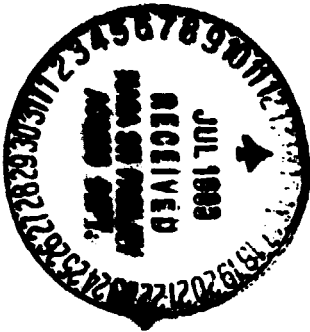
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Cornell University  
School of Civil and Environmental Engineering

REMOTE SENSING PROGRAM



SUMMARY REPORT

June 1972 - May 1983

NASA Grant NGL 33-010-171

(83-10304) REMOTE SENSING PROGRAM Summary  
Report, Jun. 1972 - May 1983 (Cornell Univ.,  
Ithaca, N. Y.) 23 p HC A02/MP A01 CSCI 05B

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Remote Sensing Program  
Cornell University  
Hollister Hall  
Ithaca, New York 14853

June 1983

## INTRODUCTION

Begun in 1972, Cornell's NASA-sponsored Remote Sensing Program has strengthened instruction and research in remote sensing, building upon Cornell's thirty years of experience in aerial photographic studies; established communication links; and conducted numerous applied research projects for or with town, county, state, federal and private organizations in New York State.

## REVIEW OF ACCOMPLISHMENTS

(1 June 1972 - 31 May 1983)

### General Achievements

- Many remote sensing projects have generated tangible benefits or actions by users, cooperators and other beneficiaries.
- Consultations and demonstrations have repeatedly resulted in various degrees of remote sensing technology transfer.
- Communication, consultations and demonstrations of the applicability and value of remote sensing have increased the awareness of officials of federal, state, regional, county, local and private agencies, particularly in New York State.
- Remote sensing communication links within and beyond the University community have been increased through newsletters, seminars, orientation sessions and conferences.
- Cornell's remote sensing research and instruction have been strengthened through additional staff, continued opportunities for expanding staff expertise, and acquisition of new data and equipment.
- Enrollment in remote sensing courses has increased substantially, and new courses have been developed.
- New remote sensing research grants and contracts were directly or indirectly attributable to the NASA grant.

### Applied Research Projects

In accordance with NASA guidelines, each project has been, in some way, unique; essentially noncompetitive with commercial firms; and aimed at producing tangible benefits or actions. Relatively little emphasis has been placed on technology transfer, per se. Completed projects that have met these requirements are listed chronologically with reference to one of the Program's Semi-Annual Status Reports. The report cited will contain the best description of the project; however, the project will normally be mentioned in at least one earlier status report. Follow-up items, such as

letters or news items, may also be found in subsequent status reports. The projects are numbered and categorized by agency participation and data source in Tables 1 and 2, and their geographic location is shown in the figure.

1. **Unique natural resources** of Tompkins County, N.Y., identified for inclusion in county's environmental plan; county report published, and data provide an information base for county and town planning. [Dec. 1973].
2. **Interconnected waterways** in Tug Hill Region, N.Y., identified with Landsat imagery for Temporary State Commission on Tug Hill; data used in formulating recreational program recommendations to State Legislature. [June 1974].
3. **Historical sites** along Great Gully, N.Y., identified for Cayuga County Museum of History and Art; data reinforced need for ongoing efforts to preserve area as "forever natural"; new imagery used in study contracted for by U.S. Environmental Protection Agency. [June 1974].
4. **Best sites for sanitary landfill** selected in Delhi-Walton area of Delaware County, N.Y.; one recommended site tested by county and state, and now in operation. [Dec. 1974].
5. **Physical constraints to land-use development** (e.g., depth of soil over bedrock, depth to groundwater) mapped in Town of Hadley, N.Y., for N.Y.S. Adirondack Park Agency; Town of Hadley incorporated data into land-use plan, which APA requires of all 92 towns in State Park; Hadley is using data for detailed site planning. [Dec. 1974].
6. **Sources of highway construction material** (sand and gravel) located in Wayne and St. Lawrence counties, N.Y.; field-testing and site or material acquisition by counties will continue for many years. [June 1975].
7. **Drainage requirements** of new 70-hectare vineyard site evaluated for Taylor Wine Company; installation of over 11,000 meters of artificial (tile) drainage based on supplied data. [Dec. 1975].
8. **Outfalls to Canadarago Lake**, N.Y., inventoried for N.Y.S. Departments of Health and Environmental Conservation; all outfalls field-checked by State Environmental Conservation Officer for possible pollution and appropriate actions taken. [Dec. 1975].
9. **Assistance** provided to student intern in evaluating **potential park sites** for Town of Ithaca, N.Y.; information led to rejection of several sites and retention of several others subject to correction of specified limitations. [Dec. 1975].
10. **Reference base maps** of Tompkins County, N.Y., and one town within the county, updated with U-2 photos; revised maps constitute base for county and town planning as well as for town zoning; county personnel used technique to update base maps of other towns. [Dec. 1975].

11. Existing landfills between Syracuse and Cortland, N.Y., monitored for leachate in study with U.S. Environmental Protection Agency and N.Y.S. Department of Environmental Conservation; six aircraft missions contracted for by EPA; ground sampling and chemical analyses funded by grant from DEC; monitoring methodology adopted by many county, state and non-U.S. agencies, and published in 1979 as an EPA research report [Dec. 1975; June 1977].
12. Best site for farm pond identified for a local architect/planner in Ithaca, N.Y.; pond has been constructed. [Dec. 1976].
13. Vineyard crop status (health, gaps) assessed for Taylor Wine Company; fertilizer and other management levels adjusted to correct recognized deficiencies, and remote monitoring considered for operational status. [Dec. 1976].
14. Remote sensing methodology for inventorying and assessing dams developed for N.Y.S. Department of Environmental Conservation; DEC incorporated methodology into State's Dam Safety Program, and interest shown by other agencies, particularly in other countries. [Dec. 1976].
15. Physical limitations for septic tanks assessed in Caroga, N.Y., for Fulton County Planning Department; special town planning report prepared by county, and data used for zoning and related site analyses. [June 1977].
16. Geologic linears and their groundwater potential identified and analyzed for Planning Department of Fulton County, N.Y.; where needed and as is economically feasible, data will lead to follow-up ground study, in addition to being input to county's long range planning decisions. [June 1977].
17. Impact of potential development on aquifer recharge/quality analyzed for Town of Fishkill, N.Y.; data used in planning town development. [June 1977].
18. The undeveloped, 240-hectare Chimney Bluffs State Park analyzed for potential recreational development for N.Y.S. Office of Parks and Recreation; state planning for park development will be based on submitted data. [June 1977].
19. Remote sensing methods for mapping and assessing change in aquatic vegetation developed, in part, for N.Y.S. Department of Health; information on test lake used by Health Department and N.Y.S. Department of Environmental Conservation in evaluating eutrophication abatement and fisheries programs, and methods used by several other groups. [June 1977].
20. Proposed sites for power plant fly ash disposal in Niagara and Tompkins counties, N.Y., assessed for N.Y.S. Public Service Commission; site analyses provided to the power company by the state through formal, public hearings. [Dec. 1977].

22. Allegany State Park evaluated for park rehabilitation and development for N.Y.S. Office of Parks and Recreation; information provides basis for improvements to the largest park in the state park system. [Dec. 1977].
23. Revolutionary War battle site evaluated for Deputy Historian of Fulton County, N.Y.; information, which allowed better definition of battle setting, was displayed in a county symposium and historic diorama, and will be used in a publication. [June 1978].
24. Mosquito breeding sites, known to be the only inland source of Eastern Equine Encephalitis in North America, characterized for N.Y.S. Department of Health; state officials correlated photo-derived and field-derived data to develop an effective spraying program. [June 1978].
25. Remote sensing methods for distinguishing land cover types related to pheasant populations analyzed for N.Y.S. Department of Environmental Conservation; DEC sought and received training through NASA's Eastern Regional Remote Sensing Applications Center, as well as additional consultations from Cornell Staff. [Dec. 1978].
26. Best site for river dredge spoil disposal and subsequent river-recreational development identified and assessed for Planning Board of Columbia County, N.Y.; recommended sites reviewed by county, town and state planners, but site development delayed because of PCB pollution problems in the river. [Dec. 1978].
27. Countywide agriculture and land capability evaluated for Planning Board of Columbia County, N.Y.; information provides physical basis for modifying boundaries of the County's eleven agricultural districts. [Dec. 1978].
28. Potential mosquito breeding sites in Rome, N.Y., inventoried for N.Y.S. Department of Health and Health Department of Oneida County, N.Y.; new photography provided by U.S. Air Force; information used by state and county in conducting field surveys, and remote sensing methods will likely be incorporated in future surveys. [Dec. 1978].
29. Analyses and consultations regarding leachate migration from Love Canal, a toxic chemical landfill in Niagara Falls, N.Y., provided to N.Y.S. Department of Health; submitted and communicated information provided primary basis for field sampling and collection of new aerial photography in this area, where some 240 residences have been evacuated; information would also be used in possible litigation; numerous requests for assistance on similar investigations received from across the U.S. and from Europe. [Dec. 1978, June 1981].
30. Sites of active and potential landsliding and erosion, in a region of known land stability problems, identified for Planning Board of Albany County, N.Y.; information used by Board in reviewing subdivision and development proposals. [June 1979].
31. A preliminary model for estimating the extent of flooding in Black River Basin developed for N.Y.S. Hudson River-Black River Regulating

District; successful refinement of model will allow real-time estimation of the extent of flooding. [June 1979].

32. The potential for expansion of sand and gravel mining in the Town of Mayfield, N.Y., assessed for the Planning Department of Fulton County; information used in developing an appropriate zoning plan. [Dec. 1979].
33. Definitions and a methodology for inventorying and characterizing beaches developed and tested for N.Y.S. Office of Parks and Recreation; methodology used by state to collect data for Coastal Zone Management Program, and possibly, inventory all beaches throughout the state. [Dec. 1979].
34. Landsliding at Camp Epworth, a church-affiliated camp at High Falls, N.Y., evaluated for the Camp Epworth Site Committee; foundation problems of the Staff Lodge were shown to be related to slope failure, and specific remedial measures were recommended. [Dec. 1979].
35. The value of Landsat for extending snow records was assessed for the N.Y.S. Office of Parks and Recreation; a technique was developed for estimating long-term snowfall conditions in areas without recording stations. [June 1980].
36. Abandoned oil wells were inventoried in the Allegany State Park for the N.Y.S. Office of Parks and Recreation; wells will be re-drilled, filled, and covered with a concrete cap to remove potential safety hazard and avoid groundwater contamination. [June 1980].
37. Potential industrial sites in Essex County, N.Y., identified and assessed for the County Planning Office for an economic development study; information used in site planning and attracting industry to the county. [Dec. 1980].
38. Different types of remotely sensed data for monitoring clearcuts in hardwood forests compared for the N.Y.S. Adirondack Park Agency, and a combined reconnaissance and detailed level method recommended; the Adirondack Park Agency acquired a digital image processing capability to implement a monitoring system which relies on Landsat images. [Dec. 1980].
39. Fuelwood availability for a ten megawatt power plant near Tupper Lake, N.Y., assessed for the N.Y.S. Energy Office; information used in an economic feasibility study by consultants to the Power Authority of the State of New York. [Dec. 1980].
40. Coniferous forests near Bath, N.Y., inventoried to assess the feasibility of a particle-board factory; information furnished to a special consultant to the N.Y.S. Department of Commerce presented to the manufacturing firm. [Dec. 1980].
41. Methodology for siting windmills developed for N.Y.S. Energy Office; methodology used to select test sites for monitoring wind power potential in three New York counties. [June 1981].

42. **Scenic views** assessed along a highway in Town of Morehouse, N.Y., for Hamilton County Planning Board; three sites recommended for roadside development examined by county and town for near-future action. [Dec. 1981].
43. **Feasibility of estimating acreage of vegetables** in mucklands assessed for N.Y.S. Crop Reporting Service; Landsat data for pilot study provided by user and USDA/SRS; follow-up project to be funded by USDA/SRS. [Jan. 1983].

Publications on several of these projects are included in the list of recent staff publications in Appendix A.

#### "Spinoff" Grants/Contracts

In general, follow-up contracts with former users have been discouraged to avoid real or perceived competition with commercial firms once feasibility had been demonstrated. Yet several contracts or grants have been a consequence of projects conducted with NASA funding. These are listed as follows:

- Location of sources of highway construction material and sites for sanitary landfill in parts of Saratoga County, N.Y.; project funded by Saratoga County. 1975.
- Historic analysis of Mills Memorial State Park, N.Y.; cooperative project funded by N.Y.S. Office of Parks and Recreation. 1976.
- A methodology for monitoring landfill leachate using remote sensing; project to compile a user-oriented manual funded by the U.S. Environmental Protection Agency (EPA). 1976-77.
- Assessment of changes in aquatic macrophytes accompanying phosphorous reduction in a eutrophic lake (Canadarago Lake, N.Y.); project funded by the Office of Water Research and Technology (OWRT), U.S. Department of the Interior (USDI). 1976-77.
- Assessment of aquatic vegetation with satellite-derived data; project funded by OWRT, USDI. 1977.
- Development of a remote sensing methodology for assessing dam flooding hazards for New York State Dam Safety Program; project funded by OWRT, USDI. 1977-78.
- Evaluation of the likelihood and whereabouts of leachate migration from some 40 landfills in the Niagara Falls area of New York; project funded by the N.Y.S. Department of Health. 1978-1981.
- Development of a model for estimating the extent of river flooding with satellite and in situ data (Black River, N.Y.); project funded by OWRT, USDI. 1979-1980.
- Development of a method for optimizing the evaluation of lake water quality through analysis of existing remotely sensed data (Oneida Lake, N.Y.); project funded by OWRT, USDI. 1980-1981.



- Remote sensing consultations; funded under a cooperative agreement between Cornell and the EPA on "Study of Advanced Technologies for Environmental Monitoring and Measurement." 1980-1983.
- Assessment of the feasibility of characterizing acid lakes using digital analyses of Landsat data; subcontract from a project funded by a Mellon Foundation grant to Dr. G. Likens, Cornell University. 1981-ongoing.
- Determine and test the feasibility of characterizing the contents of liquid chemical waste storage drums through thermal remote sensing; project funded by EPA. 1982 and 1983.
- Engineering analyses of crop inventory through remote sensing; project being funded by Statistical Reporting Service, U.S. Department of Agriculture. 1983-1986.

### Communication and Instruction

**Contacts** -- Members of the Program staff have worked cooperatively or examined possible projects with representatives of many groups. These are summarized in Table 3, where the various groups have been categorized according to whether their representatives: (1) cooperated in one or more projects, (2) were users of the results of a project in which they may or may not have participated, or (3) were involved in either preliminary discussions or discussions which have not as yet led to a specific project. Included in Table 3 are those projects whose agency participation was outlined in Table 1.

The numbers in Table 3 give relatively little appreciation for the actual level of agency contact; especially, since the numbers do not reflect repeated contacts with the same agency. To illustrate, the Program staff has worked with several divisions of the N.Y.S. Department of Health (i.e., projects 8, 19, 24, 28 and 29), in addition to providing remote sensing consultations on various other tasks.

In addition to hosting project-related visitors and invited speakers for the weekly Seminar in Remote Sensing (below), the Program staff has participated in many national and international symposia and received numerous guests from within the United States as well as from many other countries. Notably, two visiting scholars from the People's Republic of China spent two years working with the Program.

**Newsletter and News Releases** -- Although conceived as a vehicle for eliciting and retaining the interest of the Cornell community, the Program's "Cornell Remote Sensing Newsletter" is now received by nearly 600 individuals and groups in some 45 states and 25 countries.

Over the past few years, Program investigations have been the subject of several news releases which received national distribution. Semi-popular articles have appeared in such diverse journals as "Aerial Applicators," "Better Roads," "Electro-Optical Systems Design," "Environmental Science and Technology," "The Professional Photographer," "Solid Wastes Management," and "Wines and Vines"; along with being featured in various newspapers and on several radio newscasts and interviews.

**Seminars** -- The Program's weekly Seminar in Remote Sensing has brought experts from government, industry and other institutions to Cornell to discuss current research, issues and applications of remote sensing with students, staff, faculty and other interested persons. The agencies represented by the approximately 180 speakers, to date, are listed in Table 4.

**Orientation Sessions** -- Cornell University receives many visitors each year, and members of the Program staff are frequently called upon to give remote sensing lectures or workshops for individuals, small groups and larger gatherings. Typical of the audiences at the more formal sessions are:

- Central New York Region, American Society of Photogrammetry; approximately 40 regular and student members of ASP and guests from central New York (Biennially).
- Cornell freshman orientation; parents of incoming freshmen engineering students (1975).
- Annual School for New York State Highway Superintendents and special workshop; some 200 town, county and state highway officials (1976).
- Cornell Summer Institute on Policies for Science and Technology in Developing Nations; institute sponsored by U.S. Agency for International Development (AID) for some 25 mid-career professionals from more than 15 countries (1976 and 1977).
- Soil Resources Inventories Workshop; AID-sponsored workshop for some 30 distinguished soil scientists from nine countries (1977).
- St. Lawrence Section, American Society of Engineering Education; educators and practicing engineers from Ontario, Quebec and upstate New York (1978).
- Cornell Soil Science Institute; 30 practicing soil scientists with the Soil Conservation Service, U.S. Forest Service and Bureau of Land Management, from across the United States (1978).
- Multi-Regional Project on Science, Technology and Development; AID-sponsored project involving high-level government and agency representatives of some 30 countries (1978).
- Workshop on Remote Sensing of the Love Canal Landfill; 20 scientists and lawyers from the New York State Department of Health and Attorney General's Office (1980).
- Minicourse on Remote Sensing; 20 Cornell faculty and staff from eight departments (1980).
- Workshop on Agricultural and Rural Development in China; 150 participants from U.S. and China (1981).

Members of the Program staff have also traveled to deliver numerous small group and agency briefings on remote sensing, normally in conjunction with project solicitation. These are in addition to responding to frequent requests for consultations, as noted above.

**Special Consultations --** Members of the Program staff have participated in special consultations, workshops, and reviews of programs for national and international agencies. Most notable of recent activities are:

- United Nations, Food and Agricultural Organization [UN/FAO]: (in People's Republic of China) participate in remote sensing workshop (1979).
- U.S. Agency for International Development [AID]: (in Thailand and Philippines) review national remote sensing programs (1979).
- TAMS Inc.: (in Chile) provide remote sensing consultations on national natural resources inventory project (1979).
- United Nations Development Programme: (in Bangladesh) review national remote sensing program and develop plan for follow-up effort (1981).
- AID: (in Ecuador, Morocco, Sierra Leone and Philippines) review countries' use of remote sensing in area frame sampling for crop statistics (1981).
- UN/FAO: (in People's Republic of China) provide remote sensing consultations on project concerned with developing livestock production (1982).
- Spectral Data Corp. and AID: (in Kenya and Zambia) conduct soil mapping investigations (1982).
- UN/FAO: (in Syria) coordinate project on developing remote sensing techniques for agriculture (1982-83).
- People's Republic of China: (in PRC) provide general remote sensing consultations to Ministry of Railways and other groups (1983).

**Curriculum and Students --** The Program staff has continued to upgrade Cornell's longstanding curriculum in Aerial Photographic Studies and Remote Sensing, placing greater emphasis on higher altitude and satellite data, non-photographic sensors and sensing techniques, and digital image analysis. With NASA support, three new courses, "Remote Sensing: Fundamentals," "Remote Sensing: Environmental Applications," and a "Seminar in Remote Sensing," were developed as part of the regular curriculum of the School of Civil and Environmental Engineering and pilot courses on digital image processing and pattern recognition have been offered (Appendix B). The enrollments in these and other remote sensing courses are recorded in Table 5.

Along with taking formal courses in remote sensing, students may also perform independent study or research through special courses, professional master's design projects, or through M.S. or Ph.D. theses (Appendix C). A relatively high proportion of students who major, minor or take courses in remote sensing consists of foreign students. Countries represented by recent graduate students are: Australia, Brazil, Burma, Colombia, Costa Rica, Denmark, Ethiopia, Germany, Japan, Kenya, Libya, Mexico, Nigeria, Philippines, Sudan, Thailand, Trinidad and Tobago, Turkey, United Kingdom, and Venezuela. A university education in remote sensing serves to

complement the shorter term training that representatives of these countries may receive elsewhere.

### Data and Facilities

The Program staff has endeavored to acquire and develop interpretation capabilities with a wide range of aircraft and satellite-derived data. With NASA assistance, the Program has received Landsat, Skylab, and high, medium and low altitude aircraft photographic and scanner coverage of sites in the Northeast. To support Program research, the U.S. Environmental Protection Agency has also obtained multispectral coverage over selected test sites; and in the course of various projects, imageries have been acquired from the U.S.A.F. Rome Air Development Center, the U.S. Geological Survey, the U.S. Department of Agriculture, the St. Lawrence Seaway Development Corp., the National Air Photo Library of Canada, the TriState Regional Planning Commission, the National Archives, Eastman Kodak Company, and several commercial firms. In addition, the NASA Johnson Spacecraft Center has supplied the Program with copies of selected surplus films.

In an effort to increase data analysis capabilities for members of the Program staff, cooperators, students and other interested users, the Program has acquired a densitometer, a more versatile zoom stereoscope, a functional but relatively inexpensive color-additive viewer, and a Stereo Zoom Transfer Scope. These instruments supplement the standard image analysis equipment obtained with non-NASA funds (i.e., zoom and non-zoom stereoscopes, a monoscopic Zoom Transfer Scope, stereoplotters and other photogrammetric and photographic instrumentation), and equipment available through other Cornell departments (i.e., density slicer and spectroradiometers).

In addition to maintaining a file of routines for batch analysis of multispectral digital data on Cornell's central computer, the Program recently acquired an I<sup>2</sup>S Model 70 image analysis system which operates in conjunction with the VAX 11/750 computer of the School of Civil and Environmental Engineering. Funding was from the National Science Foundation and other non-NASA sources.

### Program Staff

Since June 1972, the Program staff has included six professors (part-time on the Program), one senior research associate (full time), three research associates (full and part-time), five research specialists (full and part-time), four computer data analysts (part-time), one photographic laboratory technician (hourly), four graduate research assistants (part time), and some 40 graduate and undergraduate students (hourly). Over the years, consultations have been provided at no cost by many Cornell and non-Cornell personnel.

Table 1. Agency participation as cooperator (C) and/or user (U) in Cornell remote sensing projects.

PROJECT	FEDERAL*	STATE	COUNTY	TOWN/LOCAL	PRIVATE
1	C	U	C,U	U	
2					
3			U		
4		C,U	C,U		U
5				U	
6			C,U		
7					C,U
8		C,U			
9				U	
10			C,U	U	
11	C,U	C,U	U		
12					U
13					U,C
14		C,U			
15			C,U	U	
16			C,U	U	
17				U	
18		C,U	U		
19	C	C,U			C
20		C,U			U
21			C,U		
22		C,U			
23			C,U	U	
24		C,U			
25		U			
26		U	C,U	U	
27			C,U	U	
28	C	C,U	C,U		
29	U	C,U			
30			C,U		
31		C,U			
32			C,U	U	
33		C,U			
34					U
35		C,U			
36		C,U			
37			C,U	U	U
38	C	C,U			
39		C,U			
40		C,U			
41		C,U			
42			C	U	
43	C	C,U			

\* Does not include NASA

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Table 2. Remote sensing data employed in Cornell  
remote sensing projects.

PROJECT	AIRCRAFT ALTITUDE			SATELLITE
	LOW	MEDIUM	HIGH	
1		P		
2		P		LI
3	C,CI	P		
4		P		
5		P	(CI)	
6		P,(CI)	(CI)	
7		P		
8	C,CI,(T)			
9		P	(CI)	
10			CI	
11	C,CI,T	(P)	(CI)	
12		P	(CI)	
13	CI			
14		P	CI	LI
15		P		
16		(P)	CI	LI
17		P	CI	
18	C,CI	P	(CI)	
19	C,CI	P		
20		P	CI	
21		P	CI	(S)
22		P	CI	
23		P		
24		P	CI	
25			(CI)	LI,LD
26		P	CI	
27		(P)	CI	
28	P			
29	CI	P	CI	
30		P	CI	
31				LI
32		P	CI	
33		P	(CI)	(LI)
34		P		
35			(CI)	LI
36		P	CI	
37		P	CI	
38			C,CI,P	LI,LD,S
39			CI	(LI)
40			CI	LI
41			CI	
42		P		
43				(LI),LD

- Notes: (1) P-panchromatic photography, C-color photography, CI-color infrared photography, T-thermal scanner data, LI-Landsat imagery, LD-Landsat digital data, S-Skylab photography.  
(2) Secondary sources are denoted in parentheses.

Table 3. Project-related contacts of Cornell Remote Sensing Program  
(June 1972-May 1983); Cooperator, 1; User, 2; Other, 3.

AGENCY		AGENCY	
<b>Federal</b>		<b>County and Regional (Cont'd.)</b>	
Environ. Protection Agency	1,2	Planning Departs. or Commissions	
Forest Service, USDA	1	-Albany County	1,2
Nat'l. Aer. & Space Adminis.	1	-Cattaraugus County	1,3
Rome Air Dev. Center, USAF	1	-Central New York Regional	3
Soil Conserv. Service, USDA	3	-Capital District Regional	3
St. Lawrence Seaway Dev.		-Columbia County	1,2
Corporation, USDOT	1,2	-Delaware County	1,2
U.S. Geological Survey	3	-Essex County	1
		-Fulton County	1,2
		-Genesee County	3
		-Hamilton County	2
		-Monroe County	3
		-Nassau-Suffolk Co. Regional	3
		-Ontario County	3
		-Seneca County	3
		-St. Lawrence County	3
		-Southern Tier Central Regional	2,3
		-Tompkins County	1,2
		-Tri-State Regional	1,3
		-Warren County	3
		-Yates County	3
		Sanitary Landfill Commission,	
		Schuyler County	2
		Soil & Water Conserv. Districts	
		-Cayuga County	3
		-Seneca County	1,2
		-Yates County	1,2
		<b>Local and Private</b>	
		ASPLUNDH Environmental Service	1,2
		Barton Brown Clyde & Loguidice	1,2
		Boyce Thompson Institute	1,2
		Calspan Corporation	1
		Camp Epworth, High Falls, N.Y.	2
		Cargill Salt	1,2
		Eastman Kodak	1
		Int'l. Paper Co.	3
		Levatic Miller Hoffman P.C.	2
		Nature Conservancy	3
		N.Y.S. Electric & Gas Corp.	3
		New York Power Pool	1,2
		Niagara Mohawk Power Cop.	1,2
		Office of Community Develop.,	
		Oneonta, N.Y.	3
		St. Regis Paper Co.	3
		Seneca Nation of Indians	3
		Taylor Wine & other vineyards	1,2
		Town of Caroga, N.Y.	2
		Town of Fishkill, N.Y.	1,2
		Town of Hadley, N.Y.	2
		Town of Ithaca, N.Y.	2
		Town of Mayfield, N.Y.	2
		Town of Morehouse, N.Y.	2
		Various apple growers	1,2
		Woodward-Clyde Consultants	1
		Cornell University	1,2,3
<b>New York State</b>			
Adirondack Park Agency	1,2		
Agr. Exper. Station, Geneva	1		
Agriculture & Markets	3		
Allegheny State Park &			
Recreation Commission	2		
Black River Reg. District	1,2		
Central New York State Park			
& Recreational Commission	1,2		
Cooperative Extension	3		
Crop Reporting Service	1,2		
Department of Commerce	2		
Dept. Environ. Conservation	1,2		
Department of Health	1,2		
Dept. of Transportation	3		
Economic Development Board	2		
Energy Office	1,2,3		
Finger Lakes Parks Comm.	3		
Geological Survey	1		
Office Parks & Recreation	1,2		
Power Authority	2		
Public Service Commission	1,2		
St. Lawrence-E. Ontario			
Commission	1,2		
Soil & Water Conservation			
Committee	1		
Temporary Comm. Tug Hill	2		
<b>County and Regional</b>			
Cayuga Museum History & Art	1,2		
Cooperative Extension			
-Albany County	3		
-Dutchess County	3		
-Yates County	3		
-Wyoming County	3		
County Historian, Fulton Co.	1,2		
Environ. Control Dept.,			
Suffolk County	3		
Environ. Manage. Councils			
-Cayuga County	3		
-Cortland County	1,3		
-Monroe County	3		
-Rockland County	3		
Health Dept., Oneida County	1,2		
Highway Departments			
-Saratoga County	1,2		
-St. Lawrence County	1,2		
-Wayne County	1,2		

Table 4. Affiliations of Cornell remote sensing seminar speakers (through May 1983).

<u>FEDERAL</u>	<u>STATE AND PUBLIC</u>	<u>PRIVATE</u>
BLM	Amer. Assoc. Advan. Science	Aero Service
DMATC	N.Y.S. Economic Devel. Board	AGA
NASA/Goddard	N.Y.S. Energy, Research and	Barnes Eng'g.
NASA/Hqtrs.	Development Authority	Barringer Research
NASA/Langley	N.Y. Geological Survey	Bausch & Lomb
NASA/Lewis	Tri-State Regional Planning	Bendix
NOAA/NESS	Commission	Block Eng'g.
NOAA/NOS	Jet Propulsion Laboratory	Calspan
NOAA/NWS	Environmental Research	Computer Sciences
Natl. Park	Institute of Michigan	Daedalus
Service	Smithsonian Astrophysical	Dames & Moore
NRL	Observatory	D'Appolonia
USACE	Smithsonian Center for	Consulting Engrs.
USAETL	Earth & Planetary Studies	Development
USAF/CRL	Whittlesey Foundation	Resources &
USAF/RADC		Transportation
USAID	<u>EDUCATION</u>	Earth Satellite
US Bu. Mines	Columbia	Eastman Kodak
USCG	Cornell	Environ. Research
USDA/ARS	Pennsylvania State	& Technology
USDA/FS	Purdue	Ebasco Services
USDA/SRS	Rhode Island School	Exxon Research & Eng'g.
USDOE	of Design	Fairchild Camera
USDOT/FHWA	Rochester Institute	& Instrument
USEPA	of Technology	Farnsworth-Cannon
USGS	SUNY Albany	General Electric
	SUNY Binghamton	HRB-Singer
	SUNY Oneonta	Inst. Advanced
	SUNY Geneseo	Computation
	SUNY Syracuse	IBM
		Lockwood, Kessler
		& Bartlett
		Martin Marietta
		McIntosh & McIntosh
		Optronics
		PAR Technology
		Satellite Hydrology Assoc.
		Spectral Data
		Raytheon/Autometric
		Westinghouse
		Woodward-Clyde
		Consultants
<u>FOREIGN</u>		
Canadian:		
Bird and Hale Ltd.		
Canadian Centre for Remote Sensing		
Defence Research Establishment,		
Ottawa		
Forestry Service		
Geotrex Ltd.		
Inland Waters Directorate		
Lands Directorate		
Ontario Ministry of Transport		
and Communication		
Topographical Survey		
University of Waterloo		
Other:		
Joint Research Center, Italy		
United Nations		

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Table 5. Typical enrollment in Cornell "remote sensing" courses.

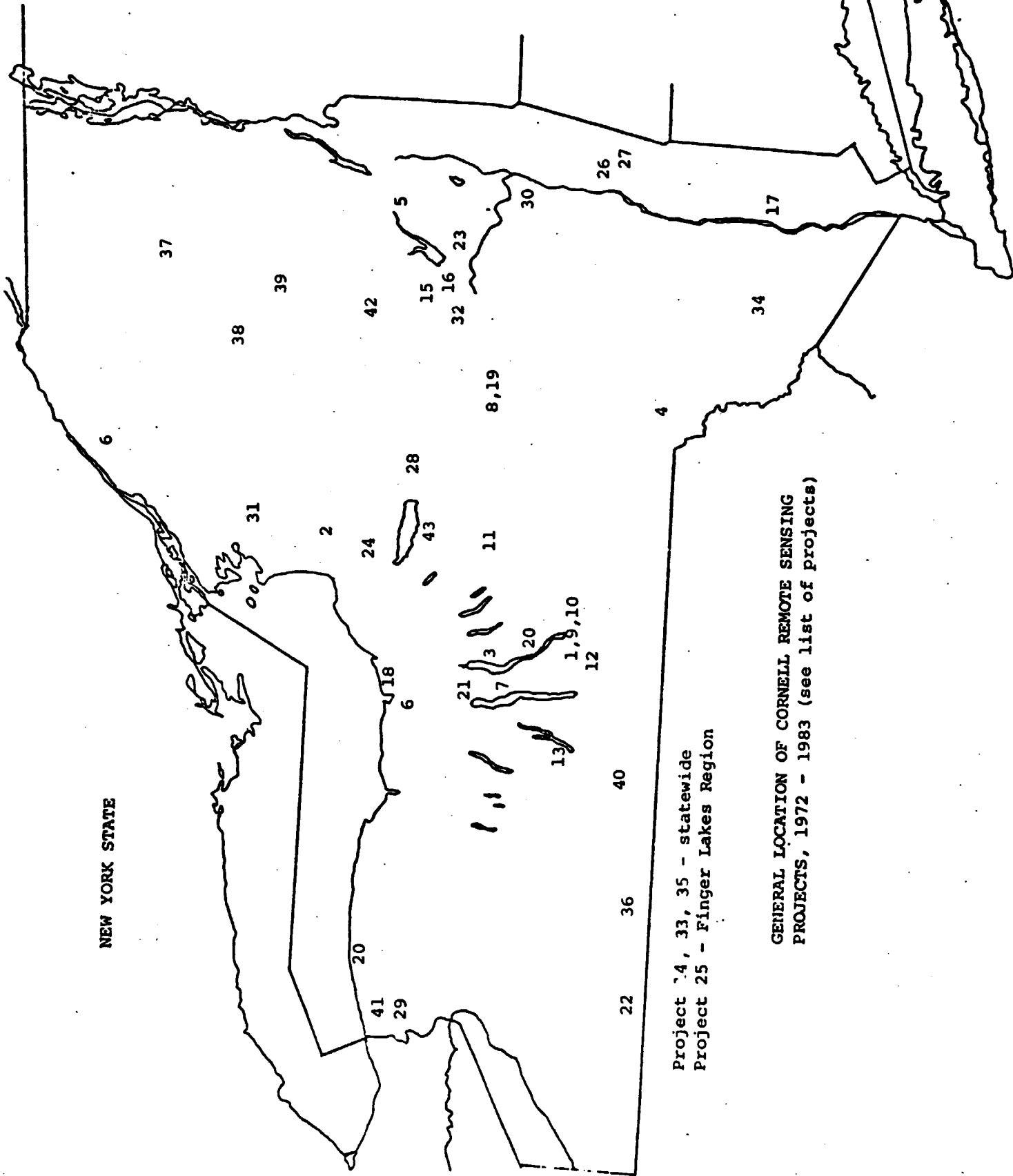
COURSES*	NUMBER STUDENTS EACH SEMESTER	
	FALL	SPRING
Remote Sensing: Fundamentals	12	--
Remote Sensing: Environmental Applications	--	27
Physical Environment Evaluation§	16	--
Image Analysis I: Landforms	32	--
Image Analysis II: Physical Environments	--	7
Special Topics†	8	6
Project and Research (including thesis research)	4	4
Seminar in Remote Sensing	--	38

\* List does not include related courses in geodetic or survey engineering, electrical engineering, space sciences, or other soil, geology, natural resources, or similar course which might offer lectures or laboratories on remote sensing.

§ Not offered 1981-81 or 1982-83.

† During 1982-83, "Digital Image Processing" and "Pattern Recognition" were offered under Special Topics. These will likely become regular courses.

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## APPENDIX A

### RECENT PUBLICATIONS (listed chronologically)

Philipson, W.R. & T. Liang. 1975. Airphoto analysis in the tropics: Crop identification. p. 1079-1092. In Proc. 10th Int'l. Sympos. Remote Sensing of Environment. Held Ann Arbor, Mich. Environ. Research Inst. Mich., Ann Arbor, Mich.

Tyl, I. & T.L. Erb. 1975. Comparison of interpretations and combined analysis of Landsat data and the Magnetic Anomaly Map of Guyana. Presented @ 10th Inter-Guayana Geological Conf. Belem, Brazil. 14 p.

Sangrey, D.A., W.L. Teng, W. R. Philipson & T. Liang. 1976. Remote sensing of ground and surface water contamination by leachate from landfill. Paper 15-1. In Proc. Int'l. Conf. Environ. Sensing & Assessment. Held Sept. 1975, Las Vegas. Inst. Electrical & Electronics Engrs., N.Y., N.Y.

Markham, B.L., W.R. Philipson & A.E. Russell. 1977. Airphoto assessment of changes in aquatic vegetation. p. 504-516. In Proc. 43rd Ann. Mtg. Amer. Soc. Photogrammetry. A.S.P., Falls Church, Va.

Philipson, W.R. & D.A. Sangrey. 1977. Aerial detection techniques for landfill pollutants. In Proc. 3rd Annual EPA Research Sympos. on Management of Gas & Leachate in Landfills. Held St. Louis. Environ. Protection Agency, Washington, D.C. 11 p.

Liang, T. & W.R. Philipson. 1977. The use of airphoto interpretation and remote sensing in soil resources inventories, with special reference to less-developed countries. p. 115-122. In Soil Resource Inventories. Proc. of AID-sponsored Workshop. Held Cornell Univ. Dept. of Agronomy, Cornell Univ., Ithaca, N.Y.

Philipson, W.R., T. Liang, T.L. Erb & B.L. Markham. 1978. Cornell's Remote Sensing Program: Remote sensing for the user. p. 64-73. In Proc. 44th Ann. Mtg. Amer. Soc. Photogram. A.S.P., Falls Church, Va.

Rib, H.T. & T. Liang. 1978. Recognition and identification. Chap. 3, p. 34-80. In Landslides; Analysis and Control. Transport. Research Board. Spec. Report 176. National Academy of Science, Washington, D.C.

Berger, J.P., W.R. Philipson & T. Liang. 1979. A methodology for dam inventory and inspection with remotely sensed data. p. 56-67. In Proc. 45th Ann. Mtg. Amer. Soc. Photogram. A.S.P., Falls Church, Va.

Liang, T. 1979. Tropical regions: Photo interpretation and engineering applications. (invited paper). p. 434 (abstract) In Proc. 45th Ann. Mtg. Amer. Soc. Photogram. A.S.P., Falls Church, Va.

McLeester, J.N. & W.R. Philipson. 1979. Developing in situ flood estimators using multi-date Landsat imagery. p. 625-637. In Proc. 45th Ann. Mtg. Amer. Soc. Photogram. A.S.P., Falls Church, Va.

Philipson, W.R., T.L. Erb, D. Fernandez & J. N. McLeester. 1980. Remote sensing for vineyard management. p. 371-378. In Proc. 46th Ann. Mtg. Amer. Soc. Photogram. A.S.P., Falls Church, Va.

Erb, T.L., W.R. Philipson, W. L. Teng & T. Liang. 1980. Analysis of landfills with historic airphotos. p. 15-23. In Proc. ASCE/ASP Specialty Conf. on Civil Eng'g. Applica. of Remote Sensing. Amer. Soc. Civil Engrs., N.Y., N.Y.

## PUBLICATIONS, cont'd.

- Philipson, W.R., 1980. Problem-solving with remote sensing. Photogram. Eng'g. & Remote Sensing 46:10:1335-1338.
- Philipson, W.R. & W.R. Hafker. 1980. Manual versus digital Landsat analysis for modeling river flooding. p. RS-3-D-1 to 10. In Proc. Fall Tech. Mtg. Amer. Soc. Photogram. A.S.P., Falls Church, Va.
- Berger, J.P. & W.R. Philipson. 1980. High altitude photos for inactive mines. Jour. of the Surveying & Mapping Div., ASCE 106:SU1:27-34.
- Duggin, M.J. & W.R. Philipson. 1981. Field measurement of spectral reflectance. p. 342-350. In Proc. 47th Ann. Mtg. Amer. Soc. Photogram. A.S.P., Falls Church, Va.
- Stanturf, J.A., W.R. Philipson, L.K. Balliett & K.L. Jahn. 1981. Remote sensing for forest applications in New York: Two case studies. p. 73-80. In Proc. 2nd Eastern Regional Remote Sensing Applica. Conf. NASA Conf. Publ. 2198. NASA, Washington, D.C.
- Philipson, W.R. & T. Liang. 1981. A remote sensing curriculum for engineers and other professionals. p. 138-140. In Proc. Conf. on Remote Sensing Education (CORSE-81). NASA Conf. Pub. 2197. LARS, Purdue Univ., W. Lafayette, Ind.
- Philipson, W.R. & W.R. Hafker. 1981. Manual versus digital Landsat analysis for delineating river flooding. Photogram. Eng'g. & Remote Sensing. 44:9:1351-1356.
- Erb, T.L., W.R. Philipson, W.L. Teng & T. Liang. 1981. Analysis of landfills with historic airphotos. Photogram. Eng'g. & Remote Sensing. 47:9:1363-1369.
- Duggin, M.J. & W.R. Philipson. 1981. Ground-level reflectance measurement techniques: An evaluation with emphasis on the importance of spectral calibration. p. 1339-1352. In Proc. 15th Int'l. Sympos. Remote Sensing of Environment. Environ. Research Inst. of Mich., Ann Arbor, Mich.
- Philipson, W.R., K. Kozai & E.L. Mills. 1982. Developing lake sampling strategies with existing Landsat data. p. 457-468. In Proc. 48th Ann. Mtg. Amer. Soc. Photogram. A.S.P., Falls Church, Va.
- Philipson, W.R. & T. Liang. 1982. An airphoto key for major tropical crops. Photogram. Eng'g. & Remote Sensing 48:2:223-233.
- Hafker, W.R. & W.R. Philipson. 1982. Landsat detection of hardwood forest clearcuts. Photogram. Eng'g. & Remote Sensing 48:5:779-780.
- Minden, K.A. & W.R. Philipson. 1982. Grapevine canopy reflectance and yield. p. 430-433. In Proc. 8th Int'l. Sympos. on Machine Processing of Remotely Sensed Data. LARS, Purdue Univ., W. Lafayette, Ind.
- Duggin, M.J. & W.R. Philipson. 1982. Field measurement of reflectance: Some major considerations. Applied Optics 21:15:2833-2840.
- Yan, S., W.R. Philipson & W. L. Teng. 1982. An analysis of Seasat SAR for detecting geologic linears. p. 435-444. In Proc. Fall Tech. Mtg. Amer. Soc. Photogram. A.S.P., Falls Church, Va.

## PUBLICATIONS, con't.

Erb, T.E. & W.R. Philipson. 1982. Producing stereo teaching aids from aerial photographs. Photogram. Eng'g. & Remote Sensing 48:12:1859-1862.

Zhu, M.H., S.Y. Yan, W.R. Philipson, C.C. Yen & W.D. Philpot. 1983. Analysis of Landsat for monitoring vegetables in New York mucklands. p. 343-353. In Proc. 49th Ann. Mtg. Amer. Soc. Photogram. A.S.P., Falls Church, Va.

## GRANT REPORTS (<sup>1</sup>prin. investigator, <sup>2</sup>co-prin. investigator, <sup>3</sup>co-investigator)

Markham, B.L. W.R. Philipson<sup>3</sup>, J. Ng and T. Liang<sup>1</sup>. 1977. Assessment of aquatic vegetation with satellite-derived data. Research Project Tech. Completion Report, Project No. A-082-NY. Office of Water Research and Technology, USDI, Washington, D.C. 16 p.

Markham, B.L. W.R. Philipson<sup>3</sup>, T. Liang<sup>1</sup> and D.M. Green. 1977. Changes in aquatic macrophytes accompanying phosphorus reduction in a eutrophic lake in New York State: An assessment based on remotely sensed and other data. Research Project Tech. Completion Report, Project No. A-069-NY. Office of Water Research and Technology, USDI, Washington, D.C. 45 p.

Berger, J.P., W.R. Philipson<sup>1</sup> and T. Liang<sup>3</sup>. 1978. Remote sensing assessment of dam flooding hazards: Methodology development for the New York State Dam Safety Program. Research Project Tech. Completion Report, Project No. A-081-NY. Office of Water Research and Technology, USDI, Washington, D.C. 55 p.

Philipson, W.R.<sup>1</sup>, J.N. McLeester & W.R. Hafker. 1980. Development of a model for estimating the extent of river flooding with satellite and in situ data. Research Project Tech. Completion Report, Project No. A-089-NY. Office of Water Research and Technology, USDI, Washington, D.C. 20 p.

Philipson, W.R.<sup>1</sup>, W.D. Philpot & J.J. Bisogni<sup>2</sup>. 1981. Airborne thermal remote sensing for characterizing the contents of liquid chemical waste storage drums: A feasibility assessment. Environ. Protect. Agency, Las Vegas, Nev. 10 p.

Philipson, W.R.<sup>1</sup>, K. Kozai & E.L. Mills<sup>2</sup>. 1981. Optimizing the evaluation of lake water quality through analysis of existing remotely sensed data. Research Project Tech. Completion Report, Project No. A-091-NY. Office of Water Research and Technology, USDI, Washington, D.C. 29 p.

Philpot, W.D.<sup>2</sup> & W.R. Philipson<sup>2</sup>. 1983. Thermal remote sensing for characterizing the contents of liquid chemical waste storage drums: An experimental assessment of feasibility. Environ. Protect. Agency, Las Vegas, Nev. 19 p.

Staff. Semi-Annual Status Report of the Cornell Univ. Remote Sensing Program (NASA Grant NGL 33-010-171). 21 reports submitted to Nat'l. Aeronautics & Space Administration, 1972-1983. Available from NASA Scientific & Technical Information Facility or National Technical Information Service (NTIS).

## **APPENDIX B**

### **CURRICULUM IN AERIAL PHOTOGRAPHIC STUDIES AND REMOTE SENSING, 1982-83 Cornell University School of Civil And Environmental Engineering**

#### **610 REMOTE SENSING FUNDAMENTALS**

Fall. 3 credits. 2 lec, 1 lab. Prerequisite: permission of instructor. Fundamentals of sensing earth resources with sensors of electromagnetic radiation. Coverage includes sensors; sensor and ground data acquisition; data analysis and interpretation; and project design.

#### **611 REMOTE SENSING: ENVIRONMENTAL APPLICATIONS**

Spring. 3 credits. 2 lec, 1 lab. Prerequisite: permission of instructor. Applications of remote sensing in various environmental disciplines. Emphasis is on the use of aircraft and satellite imagery for studying surface features in engineering, planning, agriculture and natural resource assessments.

#### **612 PHYSICAL ENVIRONMENT EVALUATION\***

Fall. 3 credits. 2 lec, 1 lab. Prerequisite: permission of instructor. Physical environment factors affecting engineering planning decisions: climate, soil and rock conditions, water resources. Evaluation methods: interpretation of meteorologic, topographic, geologic, and soil maps, airphotos, and subsurface exploration records.

#### **613 IMAGE ANALYSIS I: LANDFORMS**

Fall. 3 credits. 2 lec, 1 lab. Prerequisite: permission of instructor. Analysis and interpretation of aerial photographs for a broad spectrum of soil, rock and drainage conditions. Specific fields of application are emphasized.

#### **614 IMAGE ANALYSIS II: PHYSICAL ENVIRONMENTS**

Fall. 3 credits. 2 lec, 1 lab. Prerequisite: CEE 612 or 613. Study of physical environments using aerial photographs and other remote sensing methods. Conventional photograph, spectral, space and sequential photography; thermal and radar imageries. Arctic, tropic, arid, and humid climate regions. Project applications.

#### **616 PROJECT**

On demand. 1-6 credits.

Students may elect to undertake a project in remote sensing and environment evaluation. The work is supervised by a professor in this subject area.

#### **617 RESEARCH**

On demand. 1-6 credits.

For students who wish to study one particular area in depth. The work may take the form of laboratory investigation, field study, theoretical analysis or development of design procedures.

#### **618 SPECIAL TOPICS\*\***

On demand. 1-6 credits.

Supervised study in small groups on one or more special topics not covered in the regular courses. Special topics may be of a theoretical or applied nature.

#### **619 SEMINAR IN REMOTE SENSING**

Spring. 1 credit. S-U grades only.

Presentation and discussion of current research developments and applications in remote sensing. Lectures by Cornell staff and invited specialists from government and industry.

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\* Not offered 1982-83

\*\*During 1982-83, "Digital Image Processing" and "Pattern Recognition" were offered under Special Topics. These will likely become regular courses.

## APPENDIX C

### THESES OF GRADUATE STUDENTS WHO MAJORED IN REMOTE SENSING School of Civil and Environmental Engineering June 1972 - May 1983

#### Doctor of Philosophy

Jamnongpipatkul, P.<sup>1</sup> 1980. Remote sensing studies of some ironstone gravels and plinthite in Thailand. 323 p.

Zall, L.S. 1976. Photo-geology and remote sensing systems for locating ore deposits. 214 p. + maps.

#### Master of Science

Aderhold, E.L.<sup>1</sup> 1981. A rangeland monitoring methodology based on Landsat data case study in the Republic of Botswana. 159 p.

Avila, R.J.<sup>1</sup> 1980. Landsat image analysis of flooding in the western llanos of Venezuela. 108 p.

Berger, J.P.<sup>1,2</sup> 1979. Detection and categorization of inactive surface mines with small scale, remotely sensed data. 104 p.

Hafker, W.R.<sup>1,3</sup> 1980. Small scale remotely sensed data for monitoring clearcutting in Pennsylvania hardwood forests. 145 p.

Kozai, K.<sup>3</sup> 1982. Developing lake sampling models by remote sensing: A case study of Oneida Lake, New York. 98 p.

Markham, B.L.<sup>1,2</sup> 1978. Monitoring aquatic vegetation with aerial photography. 149 p.

Minden, K.A.<sup>1,3</sup> 1982. A remote sensing study of concord vineyard canopy reflectance. 183 p.

Sorensen, B.M. 1976. Evaluation of landslide potential in a glaciated landscape: An aerial photographic study. 108 p. + plates.

Swe, S.N. 1976. Aerial photographic interpretation and field reconnaissance of the geology of Utuado and Adjuntas quadrangles, Puerto Rico. 116 p. + maps.

Teng, W.L.<sup>1,2</sup> 1977. Remote sensing in monitoring leachate from landfills in central New York State. 118 p.

Voigt, F.C.<sup>1,2</sup> 1974. Remote sensing applied to snow related recreational development. 94 p.

Wayumba, G.O. 1983. Development of a remote sensing methodology for analyzing shifting cultivation and grazing patterns in the semi-arid region of Kenya. 181 p.

## THESES con't

Zall, L.S. 1974. Aerial photographic and ground reconnaissance of permafrost and nonpermafrost Arctic terrain as in interior Alaska. 246 p.

## Master of Engineering (Civil)

Ackley, R.<sup>1</sup> 1974. Environmental impact statements for highways and the applications of remote sensing to their production. 53 p. + append.

Poludniak, S.R.<sup>1</sup> 1977. Remote sensing in power plant siting.

Rubin, C.S.<sup>1</sup> 1979. Remote sensing applied to mineral exploration in southern St. Lawrence County, New York. 62 p. + append. + maps.

Toaz, Jr., R.D.<sup>1</sup> 1975. Densitometric turbidity determinations from aerial photography.

Wozny, T.M.<sup>1</sup> 1980. Industrial site location in Essex County, New York. 134 p.

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<sup>1</sup> Research supported at least in part by NASA grant

<sup>2</sup> Student supported for at least one semester with assistantship from NASA grant

<sup>3</sup> Student supported on hourly basis by NASA grant